Preliminary Paper

"Systems Engineering: Practices and Tools"
Sixth Annual international Symposium of
The National Council on Systems Engineering

# Space Mission Operations Co.need

Gael F. Squibb
Manager Mission Operations Development Program Office
Jet Propulsion Laboratory - California Institute of Technology
Mail Station 303-400
4800 Oak Grove Drive
Pasadena, California 91109-8099

Voice: 818-354-4086
FAX: 818-395-3575
e-mail: gael.f.squibb@jpl.nasa.gov

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# Space Mission Operations Concept

## Abstract

Developing a Mission Operations Concept for a space mission is a system engineering process which involves multiple disciplines, working together to describe, in the terms of the operators and the users (recipients of the data from the mission) the operational attributes of the flight and ground elements of the mission. A space mission operations concept emphasizes the way the mission will be operated and used (operational characteristic) and in terms which are understood by the operators of the system and the users (the recipients of the data from the system). The Operational Attributes of a Mission are described by considering nine mission characteristics that may be traded for cost and performance attributes of the mission. It is through the process of developing a Mission Operations Concept that changes to mission requirements and/or design can be identified which will lower the Mission Life Cycle Cost. The inputs to the Mission Operations Concept include both flight, ground and management functions.

Mission Operations Concepts are typically generated for nearly all space missions. It is a requirement in many project plans and RFPs that are generated. However, there is not a definition of what is included in a mission operations concept, what should be considered when generating this operations concept, what the process is or what the products are. This paper will discuss the process of developing a space mission operations concept, the benefits of starting this system engineering task early, the necessary inputs to the process and the products which are generated. This paper is based on a chapter in a text book that will be published in January 1996- prior to the NCSC Conference. In addition this process has just started going through an international review which will result in an 1S0 Standard for a Space Mission Operations Concept checklist. This checklist will describe the inputs, and outputs required to conform to the 1S0 standard for a space mission operations concept. The paper will include that latest draft of the international standard checklist, and explain the system engineering processes and benefits of generating an operations concept early in the life-cycle of the project, during the study phase, and then maintaining the operations concept throughout the life-cycle of the project.

## What is a Mission Operations Concept?

A process which involves multiple disciplines, working together to describe, in the terms of the operators and the users (recipients of the data from the mission) the operational attributes of the flight and ground elements of the mission. Similar to the development of a space mission concept except that the Mission Operations Concept is more detailed and emphasizes the way the mission will be operated and used (operational characteristic) and in terms which are understood by the operators of the system **and** the users (the recipients of the data from the system). Typically a Mission Operations Concept will be developed for each Mission Concept that significantly changes the inputs to a Mission Operations Concept.

The Operational Attributes of a Mission are described by considering nine mission operations elements that may be traded for cost and performance attributes of the mission. It is through the process of developing a Mission Operations Concept that changes to the Mission Concept can be identified which will lower the Mission Life Cycle Cost. The inputs to the Mission Operations Concept include both flight, ground and management functions and are described in detail in the section on inputs.

## Why should a Mission Operations Concept be Developed?

Developing a Mission Operations Concept requires that different disciplines, (mission designers, S/C designers, payload designers, ground system designers, ground system operators and recipients of data from the mission operations system) communicate with each other. The way that a space vehicle is operated is often different than what the designers of the space vehicle had in mind. This early communicant ion bet ween designers, operators and users of the data from the mission shortens the development time due to fewer changes being required during the development or testing phases of the mission.

The process emphasizes areas in these disciplines where tradeoffs should be studied to minimize life-cycle costs and improve the return of information from the mission. The operations concept when documented may be used as a source of derived requirements on the development of functions of the 'mission operations system. Since the mission operations concept is responding to top level mission requirements, it is then easy to associate the derived requirements to the top level mission requirements and show requirements traceability during the design phase of the mission.

When the mission operations concept is performed early in the life cycle of a project, it often force the resolution of design incompatibilities which would otherwise have to-be solved (minimized) by operations developments or procedures..

**When should a Mission Operations Concept be Developed and What should it cover?**

Each Mission Concept should have a corresponding Mission Operations Concept. The two concepts may be developed in parallel and this process will save cycle time and reduce the conceptual and definition phase of a project, When developed in parallel, the Mission Operations Concept can feed quickly back into the development of the Mission Concept any suggestions for reducing MOS costs.

The earlier the Mission Operations Concept is conducted, the more influence the results will have on the development phase as the interfaces and attributes of the inputs are less defined, and tradeoffs can be made. Table 1 shows how the input characteristics become finalized during the pre-project phases and by the time phase C/D is started the Ground System Capabilities, AND the attendant Operations Staff are the functions that usually changes.

The Operations Concept should be emphasized during Pre-phase A, Phase A, Phase B, and the early portions of Phase C/D. Under certain conditions it can even be conducted during Phase E (Operations). When the Operations Concept is developed during phase C/D or E, the only changes that can be made are to the 9 mission operations elements. This then will be changes to the Grounds System, The People and Procedures, or the Flight S/W.

The Operations Concept should be kept updated during the life of the project. It is an excellent tutorial for new project personnel to gain an overview of the concepts that are being executed by the Mission Operations System.

## Table 1 Operational Concept Input Changes vs Mission Phase

| Operations Concept Inputs | Project Phase | | | | |
|---|---|---|---|---|---|
| | Pre A | A | B | CID | E |
| Mission Scope, Objectives and Payload Requirements | C/F | F | F | F | F |
| Mission Plan | C | C | C/F | F | F |
| Mission Philosophies, Strategies and Tactics | C | C | F | F | F |
| Programmatic Constraints | C/F | F | F | F | F |
| S/C Capabilities and Characteristics | C | C | C/F | F | F |
| night S/W | C | C | C | C/F | E/F |
| Payload Capabilities and Characteristics | C | C | C/F | F | F |
| Ground System Capabilities and Characteristics | E/C | E/C | E/C | E/F | E/F |
| End-to-End information System Characteristics | C | C | C | E/F | E/F |
| End User Data Product Definition | C | C | C | F | E/F |

F= input usually Frozen during this phase
C= Input usually changeable or being defined during this phase
Table showing which of the above inputs arc generally frozen as a function of the development phase Pre phase A through E
C/F= Changeable but only for cause and with supporting, rational (usually cost 01 performance)
E/C= 1 Existing Capabilities Defined Ncw capabilities may be defined
E/F = Existing Capabilities Frozen, Ncw capabilities may change t ut only for cause and with supporting rational (usually cost or performance)

## Attributes of an Operations Concept

Developing an Operations Concept is a process which involves multiple disciplines, working together to describe in the terms ofthc users of the system, the operational attributes of all functions of the system. It fosters a common understanding of processes among diverse elements of a project.

An operational concept stresses the way the system will be operated and used (operational characteristics) and in terms which are understood by the operators of the system AND the recipients of the data from the system. The process will focus on areas which are not understood, controversial, and drivers (cost and performance) on the system. Other areas which are identified and discusses during the process are documented for completeness. Developing an operations concept has also been shown to be a method of addressing system level technical issues which cross separate funding boundaries.

To perform an operations concept, the key interfaces and attributes placed on the Mission Operations System must be identified. The process of developing an operations concept, identifies the key interfaces within the Mission Operations System. It is only at this point that the life cycle costs of a mission concept can be determined.

## Who should be involved in developing a Mission Operations Concept?

Section xxx describes 13 functions which are used to describe a Mission Operations System. Eventually representatives of each of these functions need to be involved in the development of a mission operations concept. In the early phases (conceptual), 1 person will often represent several MOS functions.

A representative from one of the MOS functions will usually provide a person who is the facilitator and keeper of the concept. This person often comes from the System Engineering or the Mission Planning function and typically is trained in End-to-End Information System Engineering.

The Mission Concept and the Mission Operations Concept are closely linked. Some of the same individuals will be involved in both activities. The table 2 relates the MOS Function described in Section xxx, to the primary engineering discipline involved in that function and the responsibility for the inputs to and outputs from the Mission Operations Concept. When the same individual usually participates in both the Mission Concept and the Mission Operations Concept, the letters MC are included in the DISCIPLINE column, The ordering of the table is in order of the input products to the mission operations concept as shown in figure xx.

Table 2
OPERATIONS CONCEPT INPUT & **OUTPUT PROVIDERS**

| MOS FUNCTION # and Function | 1)1 S01'1,1 NE | INPUT PRODUCT | OUTPUT PRODUCT |
|---|---|---|---|

(Outline of the remaining portion of the paper follows)

## DEVELOPI NG TIIE M 1SS1ON OPERATIONS CON CEPT

**1. Identify the mission concept and supporting space mission architecture**

**2. Determine Mission Operations functions to be performed.**

**3. identify options for accomplishing functions and identify if capability exists or must be developed.**

**4. Perform trades for items identified in step 3.**

**5. Develop operational scenarios for the functions determined in step 2 and the options selected in step 4.**

**6. Develop timelines for each scenario**

**7. Allocate Steps of the scenario to H/W & S/W or people.**

**8. Develop Data Flow Diagrams**

**9. Characterize the organization and team responsibilities**

**10. Assess mission utility, complexity, and cost of mission operations**

**11. identify requirements that can be articulated, and put specifics to general top level requirements**

**The Mission Operations Concept Document**

**Document Organization and structure**